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DEVELOPMENT OF ELEMENTS OF A HIGH Tc SUPERCONDUCTING CABLE

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PROGRAM SUMMARY

The goal of the program is the development of materials and processes for the fabrication of a composite high Tc superconductor element made of a superconducting coating on a supporting fiber.

PROGRAM STATUS

The first phase of the program is the development of textured polycrystalline $YBa_2Cu_3O_7$ (YBCO) with improved current carrying capacity. Phase II is the development of materials and methods for the composite conductor fabrication. Phase III is the demonstration of the capability to form continuous conductors. The status of tasks relevant to this reporting period will be summarized. Details on specific accomplishments for this quarter will be covered in the next section.

It is not clear at this time if the inability to carry appreciable currents in polycrystalline YBCO is an intrinsic limitation of the material. Much of this quarters and next quarters efforts are directed toward clarifiying the effect of composition and process variations on the Jc of aligned polycrystalline samples.

Task I-1 Quantify the effects crystallographic orientation on Jc The effects of materials system, processing conditions and crystal alignment on Jc are being determined on our magnetically aligned samples which are probably the best aligned, bulk YBCO samples available. Although the absolute values are low, a few hundred A/cm^2 at 77K, there is very little change in Jc at applied magnetic fields up to a few tesla. It seems the current is carried by a path through only a small fraction of the grain boundaries. These boundaries do not show weak link behavior.

Task I-2 Demonstrate improvements in critical current density Recent literature has shown the Thallium-based (TBCCO) and Bismuth-based (BSCCO) materials to have less problems with weak links than YBCO. We have begun to make BSCCO by the powder in silver tube technique for comparison of properties with YBCO.

Several new compositions based on YBCO are under study to see if improvements in Jc of aligned polycrystalline materials are obtained. Work is also continuing on studying the effect of processing parameter variations on the Jc of YBCO with particlar emphasis on weak links.

Task I-3 Introduce flux pinning sites into YBCO The recent concern with flux creep in high Tc materials as well as demonstrations of the large changes possible in intra-grain Jc, has increased the need for understanding pinning centers in these materials. In addition to magnetic hysteresis loop studies of intragranular flux creep,we are also looking at the effect (if any) of foreign atom substitutions on intergranular Jc in aligned materials.

Task II-2A Substrate selection Metal substrates are preferred due to thermal expansion compatibility with YBCO. The most likely composite system will be metal substrate + oxide barrier layer + silver layer + superconductor.

Task II-2B Barrier coating selection We have demostrated that YBCO can be sintered at 900C on a silver tape when a lowered oxygen pressure is used. This allows liquid phase sintering of the YBCO while not melting the silver.

SUMMARY OF MAJOR ACCOMPLISHMENTS - Jan 90 through Mar. 90

Task I-2 FABRICATION OF ALIGNED BULK SAMPLES -- Continuing studies of process parameters used in the fabrication of magnetically aligned YBCO has shown only limited changes in the transport Jc at 77K & 0.3T. Various densities, presence or absence of second phases, and variations in oxygen annealing cycles all result in Jc values of about 75 to 200A/cm^2. Different powder sources have been used to make aligned samples. These are now in the process of being tested. Current results indicate the low Jc values are intrinsic to YBCO. Obviously this conclusion must be made less tentative and further studies are in order.

Task I-2 Jc OF ALIGNED YBCO -- The Jc values in aligned polycrystalline samples (about 100A/cm^2) are not very dependent on magnetic field. It seems that a few of the grain boundaries do not exhibit weak link behavior and are able to carry current in appreciable magnetic fields. Either the number of these few "good" boundaries needs to be greatly increased, or the Jc at these special boundaries needs to be improved. Both these ideas are "long shots" that need to checked before YBCO is dismissed as a candidate for high Jc power applications in favor of the BSCCO and TBCCO systems.

There are literature references to a material where Ca is substituted for Y and La is substitued for half the Ba resulting in a composition $CaLaBaCuO_{7-x}$ (CLBCO). This material has the same crystal structure but is reported not to show the preference for (001) boundaries seen in YBCO. The (001) grain boundaries are the predominant grain boundaries seen in both non-aligned and aligned YBCO and are suspected

to be particularly bad in terms of ability to carry supercurrents. CLBCO powder has been prepared, samples sintered, and the material is now under study. The microstructure showed much fewer (001) boundaries than typical YBCO samples. Electrical properties are now being measured.

The alternate idea of increasing the Jc of the few good boundaries in aligned material is based on the probability that these are low-angle boundaries made up of dislocation arrays. The remaining grain boundary material between the dislocations should be made up of material similar to the intragranular material. If this is the case, then it may be possible to use flux pinning sites to increase the current carrying capacity of these low angle boundaries. Samples are being prepared containing small amounts of cations likely to pin magnetic flux lines.

Task I-2 WEAK LINKS IN BSCCO -- The apparent lessened weak link behavior of BSCCO and TBCCO was pointed out in the last report. We are continuing low level efforts on fabrication of BSCCO powder in silver tube samples. In this way we will gain some familiarity with both the process and the material. BSCCO is a likely alternate if YBCO is shown to have intrinsic problems with grain boundary weak links.

Task I-3 FLUX CREEP -- Vibrating sample magnetometer measurements of intragranular Jc and flux creep in YBCO and BSCCO are continuing. Recent results on 2212-BSCCO doped with UO_2 and neutron irradiated to introduce fission track damage show an increase in intragranular Jc (50K,0.8T) of over 70 times that of the sample before irradiation.

EXTERNAL PRESENTATIONS

K W Lay, "Progress Toward a High-Temperature Superconducting Wire", talk given at SC GLOBAL 90, Jan. 18, Long Beach, CA

K W Lay, "Processing Aligned Bulk $YBa_2Cu_3O_7$ Superconductors," talk given at Hudson-Mowhawk Section of American Ceramic Society Symposium on Advanced Ceramics, March 15, Troy,NY

J E Tkaczyk, R H Arendt, J A DeLuca, M F Garbouskas, P L Karas, K W Lay, A Mogro-Campero, L G Turner, "Improved Magnetic Field Dependence of Jc in c-axis Aligned Polycrystalline High Temperature Superconductors", talk given at American Physical Society meeting March, Anaheim, CA

GOALS FOR NEXT QUARTER

Continue studies of the transport Jc of aligned sintered YBCO compacts. Flux pinning dopants and prccess variations will be

considered. Goal is to determine if improvements in Jc can be obtained.

Continue search for methods of improving Jc in polycrystalline YBCO samples by altering grain-boundary chemistry.

Continue fabrication studies of mechanically aligned, powder-in-tube, BSCCO samples to compare with magnetically aligned YBCO.

FINANCIAL STATUS

All values are cost plus fixed fee total costs.

TOTAL FUNDING REQUIRED FOR EFFORT 01Sept88 through 31Aug91 (36 months)	$2,424,530
CURRENT AUTHORIZATION 01Sept88 through 31Jan91 (29 months)	1,668,000
FUNDING EXPENDED TO-DATE 01Sept88 through 31Mar90 (19 months)	996,457